Overview of Baltimore Harbor TMDL Development Process

Prepared for the

Baltimore Harbor Stakeholder Advisory Group

HARBOR OVERVIEW

- The Baltimore Harbor is a very complex system
  - It has a unique 3-layer hydrodynamic flow pattern. The upper and lower layers carry saline water and flow inward to the head of the Harbor, while the freshwater middle layer flows outward toward the mouth of the harbor.
- This complexity necessitated a very extensive monitoring and modeling program.
- Information suggests that the Harbor has elevated levels of nutrients, metals, and organics.

Water Quality Impairments in Baltimore Harbor

- Eutrophication
  - Nutrients; Nitrogen and Phosphorus
- Sediment contamination
  - Chlordane and PCBs
  - Toxic metals (Chromium, lead, zinc)
- Human pathogens
  - (fecal coliform indicator species)
- Fish consumption advisories
  - Bottom feeding fish (Catfish, carp, eels) contain unacceptable levels of chlordane

The TMDL Process

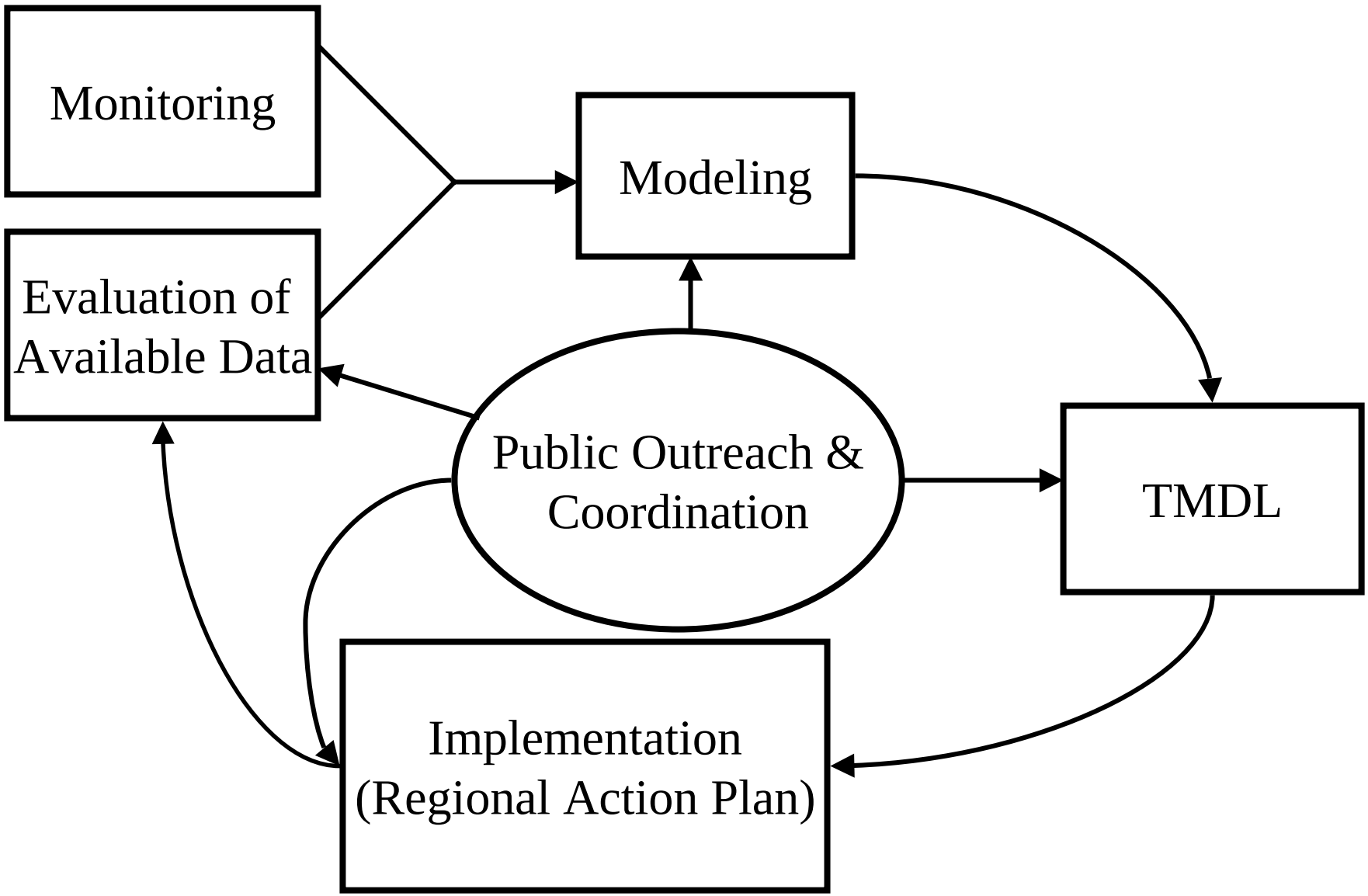
- Determine Harbor impairments - 303(d) list
- Evaluate existing data and sources
- Conduct further monitoring
- Develop models
- Determine endpoints (e.g., water quality standards)
- Develop TMDLs and allocation process

The TMDL Process Cont.

Partners in Process

- Maryland Department of the Environment
- Maryland Department of Natural Resources
- University of Maryland/Wye Research Institute
- University of Maryland/Center of Environmental Sciences
- William and Mary/Virginia Institute of Marine Sciences

The TMDL Framework

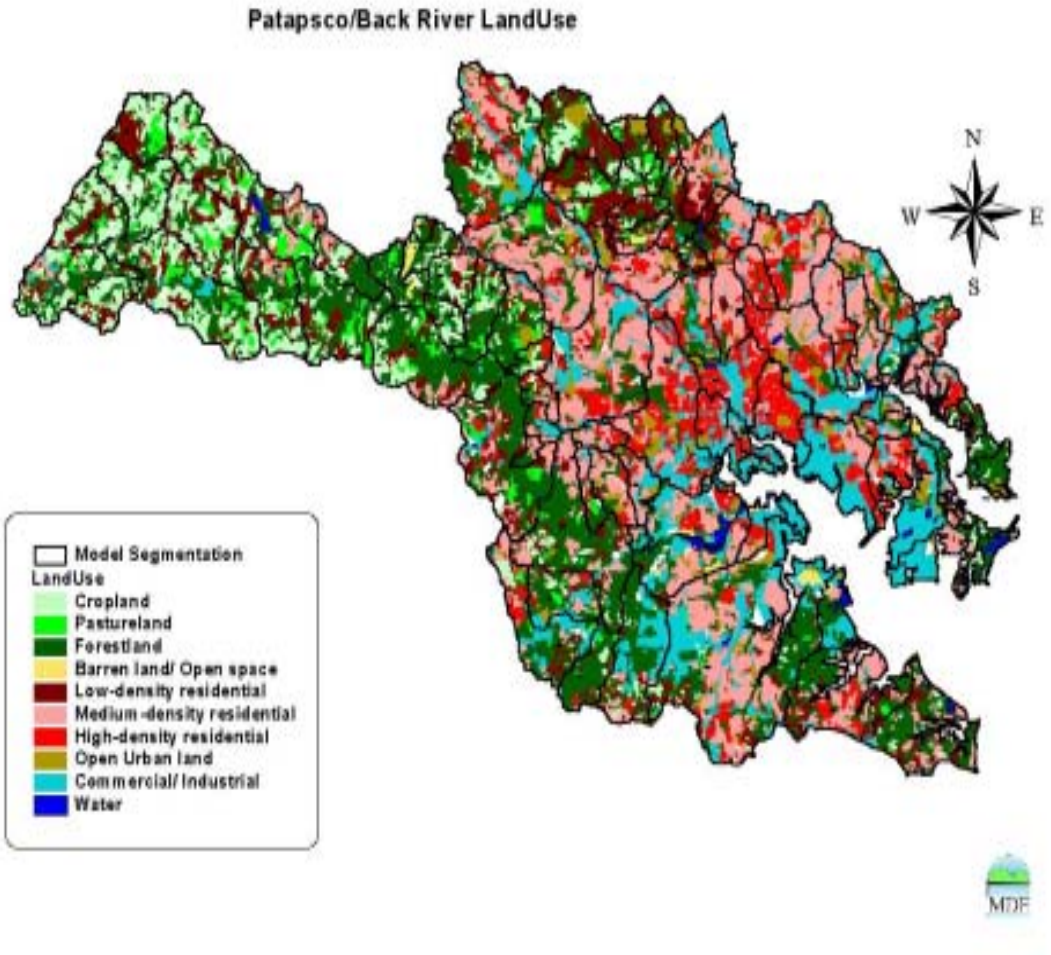


Available Data Sources

- Stream Water Column Data
- Non-Point Source
- Point source
- Sediments
- Atmospheric Deposition

Watershed Characteristics

- The watershed is home to 1.5 million people
- Landuse is predominantly industrial, commercial and residential (46%)



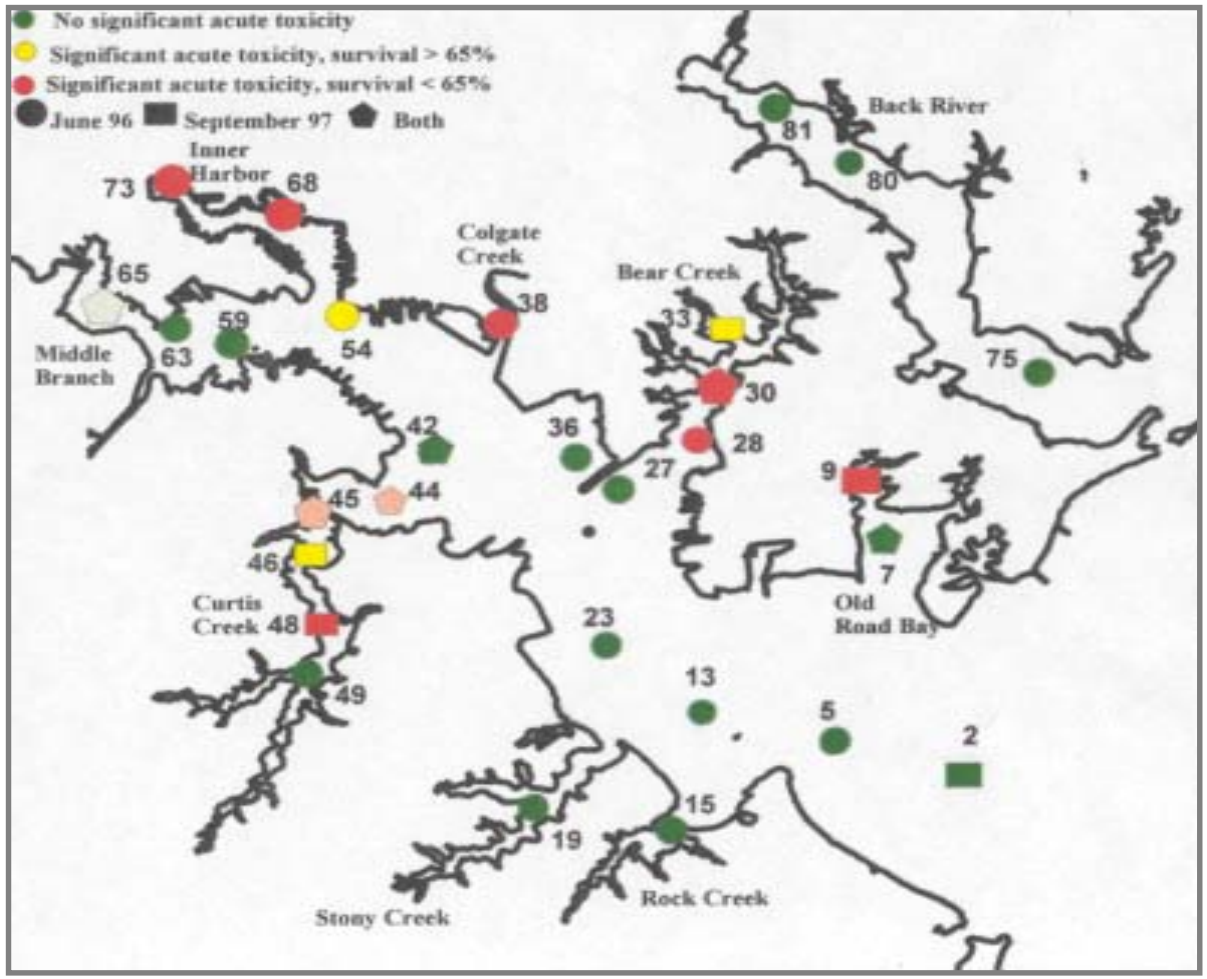
MDE

Toxics Program

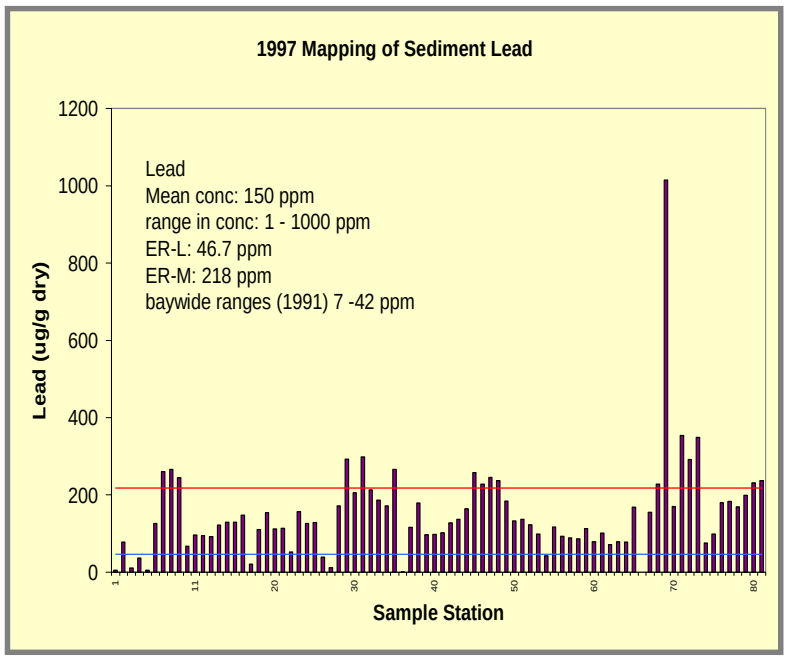
Existing Toxic Data Assessment

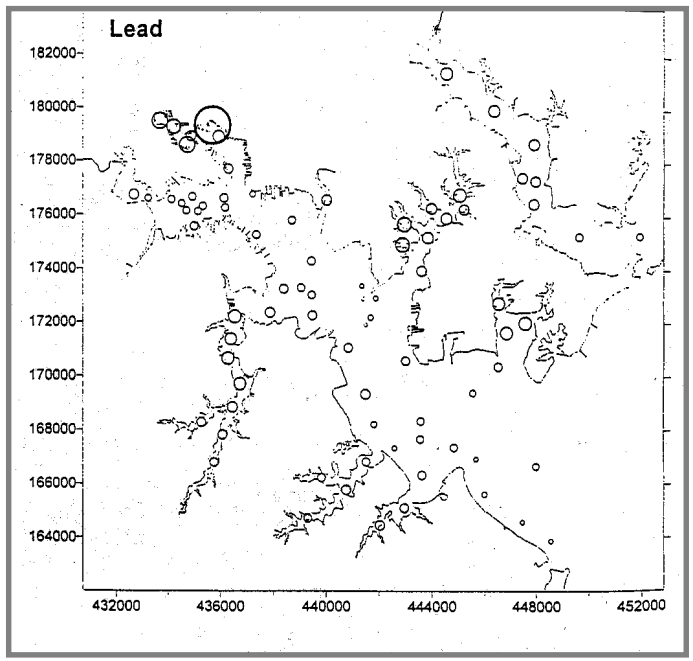
- Baltimore Harbor Sediment Mapping Study
  - Chemistry (Metals, PCBs, PAHs) – 80 Stations
  - Toxicity Study – 25 Stations
  - Benthic Community – 40 stations
- Sediment Fluxes – Baltimore City
- NPDES data for point sources and Baltimore City nonpoint sources
- Whole Effluent Toxicity (WET) program data
- Fish Tissue
- CHARM – Comprehensive Harbor Assessment and Regional Model Study (1996-2000)
- PBGM – Patapsco/Back/Gunpowder/Middle River Chemical Contaminant Survey (2001-2002)

Sediment Mapping Study Results
Toxicity



Sediment Mapping Study Results
Pb Conc.





CHARM Monitoring

- Physical Measurements
  - Three 1-month intensives during winter, spring, and summer
  - D.O., pH, TSS, Salinity and Conductivity
- Water Quality Measurements
  - Three 1-month intensives during winter, spring, and summer
  - Nutrients, metals and organics
- Point Source Measurements
  - 15 major point sources - metals and organics
- Non-point Source Measurements
  - 4 locations - metals and organics
- Atmospheric Deposition
  - 5 locations - nutrients, metals and organics

CHARM Monitoring

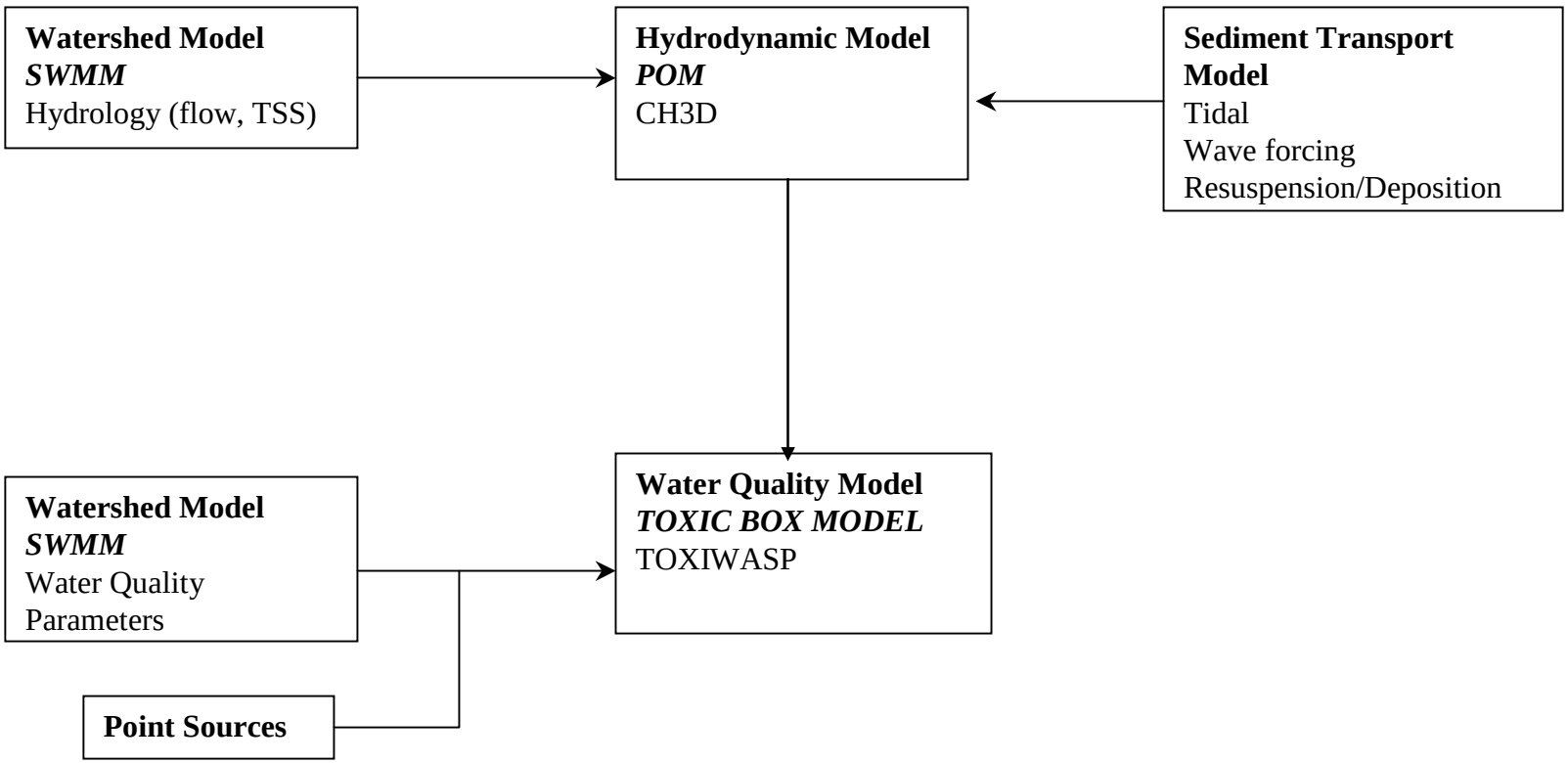
- Final results from the CHARM monitoring study are due in the near future
- A few samples from point source locations need to be re-collected

Baltimore Harbor Toxics Modeling

Harbor Toxics Modeling Program

- Watershed Modeling
  - Storm Water Management Model (SWMM)
- Harbor Specific – UM Center for Environmental Studies (UMCES)
  - Hydrodynamic/Sediment Transport Model (Princeton Ocean Model)
  - Toxics/Food Chain Model (Harbor Box Model)
- Upper Bay - Virginia Institute of Marine Science (VIMS)
  - Hydrodynamic/Sediment Transport Model (CH3D)
  - Toxics (Toxiwasp)

Harbor Toxics Modeling Framework



Toxics – Watershed Model

Storm Water Management Model (SWMM)

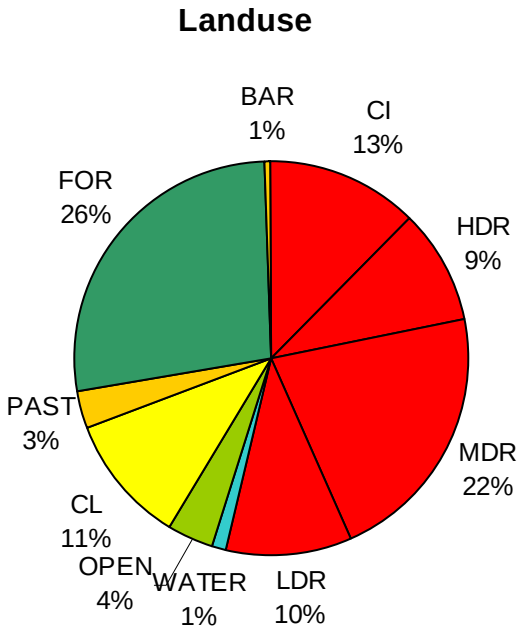
Selection Criteria

- Primarily Urban Runoff Model (wet weather flow)
- Existing Studies Available
- Existing Parameter Data Available
- Recent EPA Updates by Urban Watershed Management Branch
- Multiple Buildup/Washoff Functions
- Limited Parameters

SWMM – Model Calibration

- Focus on predominant land uses
- Calibrate Edge of Stream (EOS) loads to literature values
- Calibrate urban loads to Event Mean Concentrations (EMCs)
- Time series overlay

SWMM Landuse Loading Summary



For–Forest CL-Crop Land

Bar–Barren Pas-Pasture

CI–Commercial/Industrial

HDR–High Density Residential

MDR–Medium Density Residential

LDR-Low Density Residential

Open-open land Water-water

Patapsco/Back River watershed

Landuse	TSS (tons/yr)	Cr (lb/yr)	Cu (lb/yr)	Zn (lb/yr)	Pb (lb/yr)
CI	7,658	2,232	4,931	50,744	7,532
HDR	3,864	273	4,384	14,713	2,875
MDR	5,905	515	6,259	20,544	3,550
LDR	2,415	229	1,079	7,984	1,114
WATER	32	2	120	105	61
OPEN	596	18	355	1,393	412
CL	4,358	51	748	2,366	509
PAST	1,449	15	230	676	143
FOR	3,480	110	1,213	3,370	1,383
BAR	146	4	40	133	34
Sum	29,903	3,449	19,359	102,028	17,614

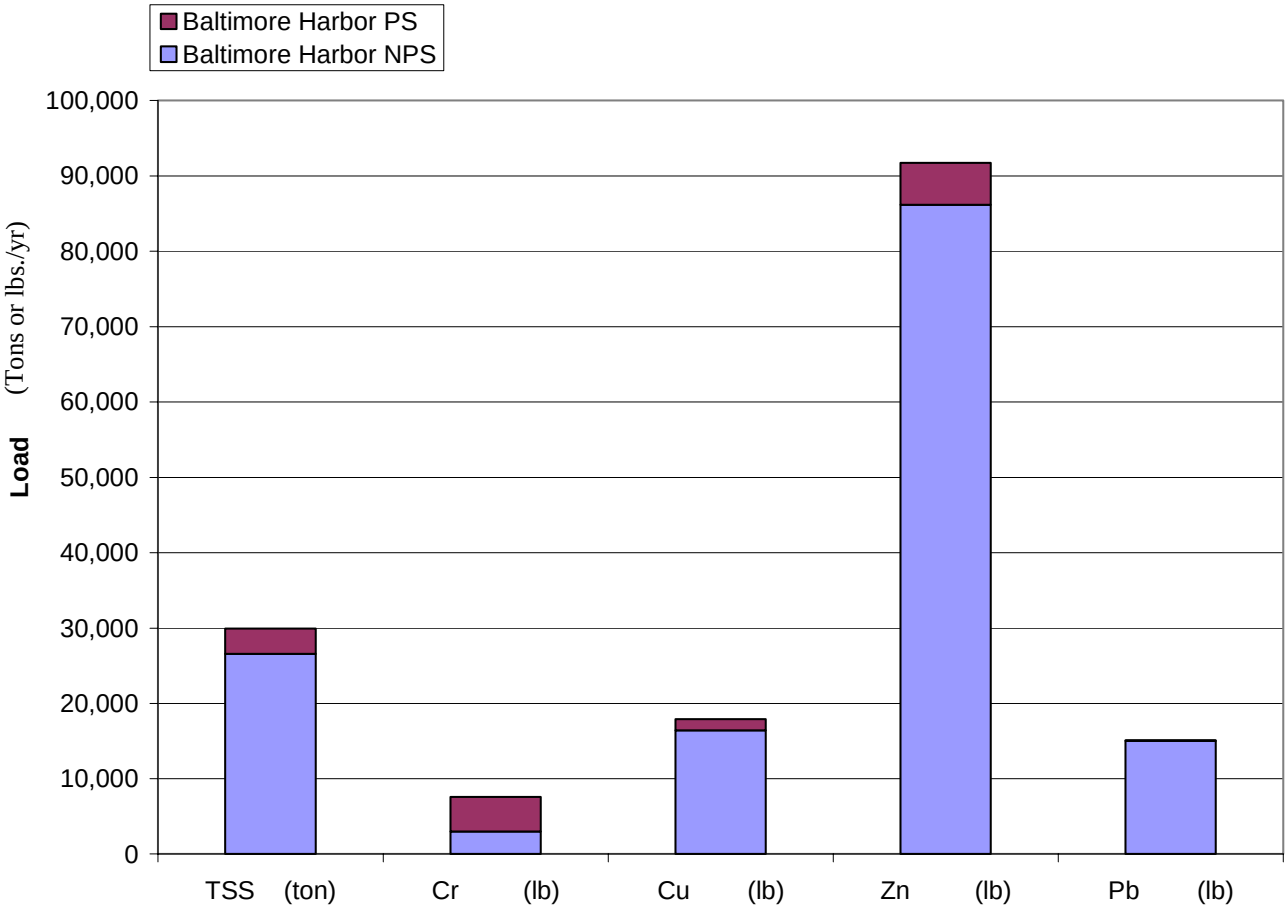
Patapsco/Back River Watershed

Landuse	TSS (tons/yr)	Cr (lb/yr)	Cu (lb/yr)	Zn (lb/yr)	Pb (lb/yr)
CI	26%	65%	25%	50%	43%
HDR	13%	8%	23%	14%	16%
MDR	20%	15%	32%	20%	20%
LDR	8%	7%	6%	8%	6%
Sum Urban	**66%**	**94%**	**86%**	**92%**	**86%**
WATER	0%	0%	1%	0%	0%
OPEN	2%	1%	2%	1%	2%
CL	15%	1%	4%	2%	3%
PAST	5%	0%	1%	1%	1%
FOR	12%	3%	6%	3%	8%
BAR	0%	0%	0%	0%	0%

Comparative Analysis of Existing Studies

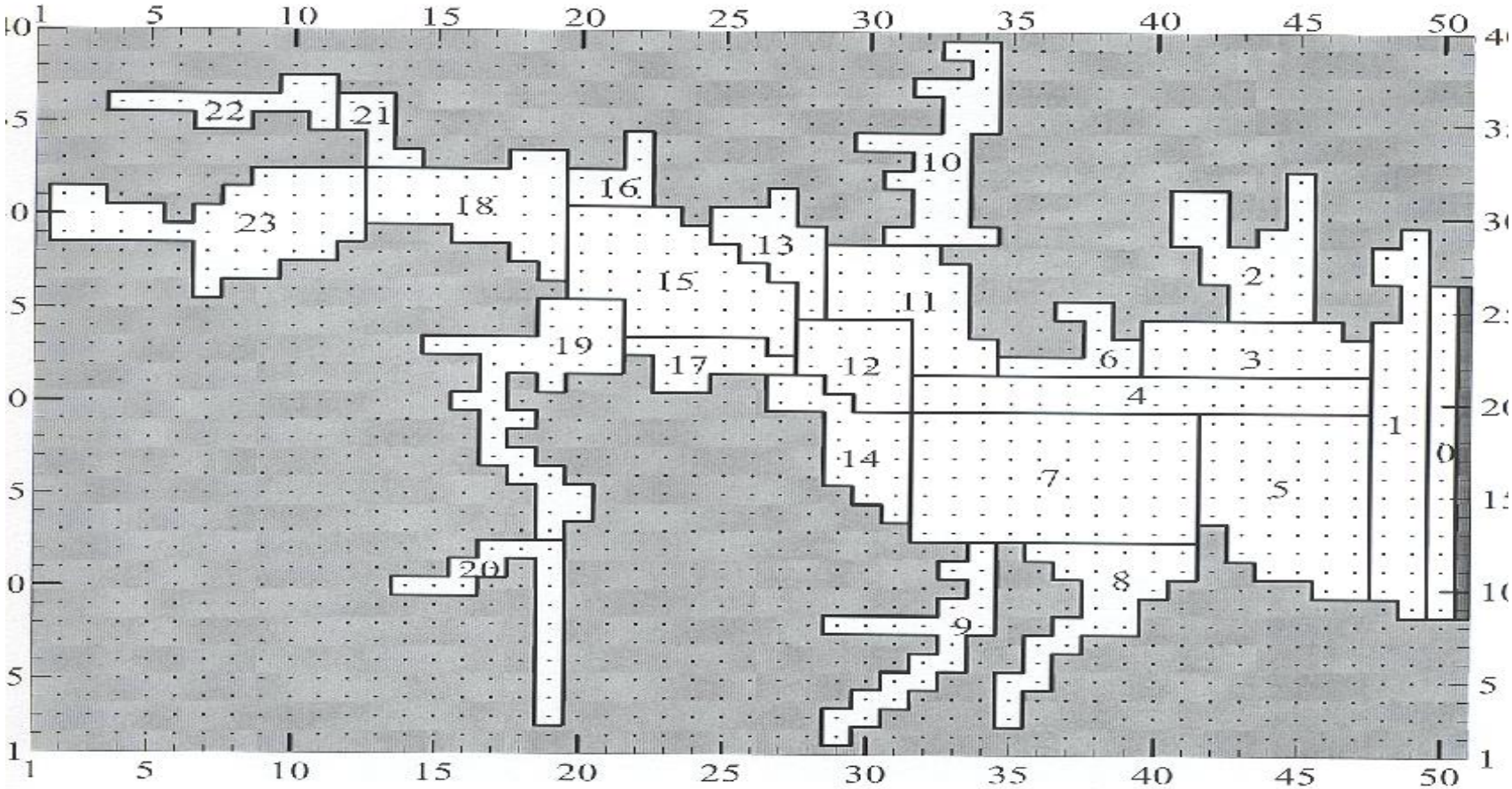
Sub Watershed	Source	Area (acre)	Flow (MG)	TSS (tons)	Cu (lbs)	Zn (lbs)	Pb (lbs)
Back River	MDE SWMM (1992 - 1999)	35,623	23,428	3,354	2,946	15,842	2,591
	MDE HSPF (1993 - 1997)	34,785	23,181	2,125			
	Back River Watershed Water Quality Management Plan (Baltimore County, 1996)			3,174	2,595	11,184	3,397
	CBP Version 4.3 (1993 - 1997)	46,851	33,208	7,298			
Harbor Watershed	MDE SWMM (1992 - 1999)	271,162	164,508	26,549			
	MDE HSPF (1993 - 1997)	266,888	179,242	24,651			
	CBP Version 4.3 (1993 - 1997)	255,952	142,209	89,407			
Upper Jones Falls	MDE SWMM (1992 - 1999)	16,946		1,350	641	3,390	559
	Jones Falls Watershed Water Quality Management Plan (Baltimore County, 1997) Sub-watersheds 1,2,3,4 & 8 year 1982	16,947		1,114	329	1,505	634

Baltimore Harbor Toxics Watershed Summary



	TSS (ton)	Cr (lb)	Cu (lb)	Zn (lb)	Pb (lb)
Baltimore Harbor NPS	26,549	2,986	16,413	86,186	15,023
Baltimore Harbor PS	3,350	4,591	1,482	5,547	100
NPS/PS	7.9	0.7	11.1	15.5	150.2

Harbor Specific
Toxic Box Model (UMCES)



Toxic Box Model Processes (UMCES)

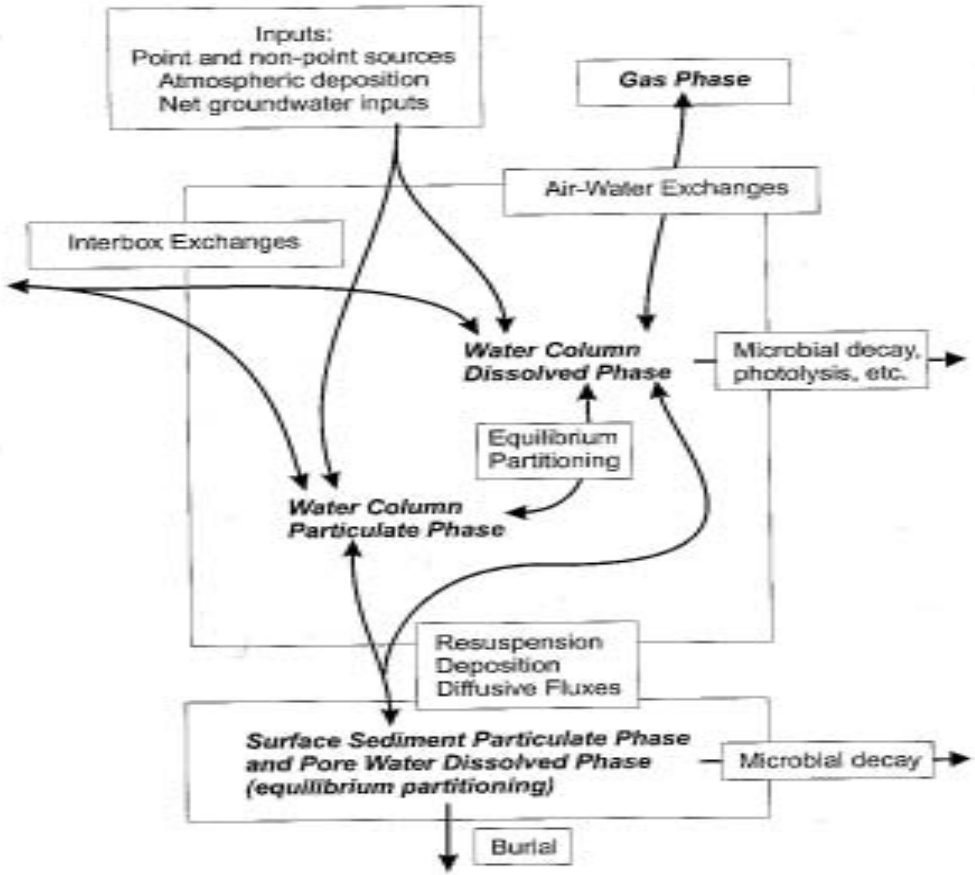
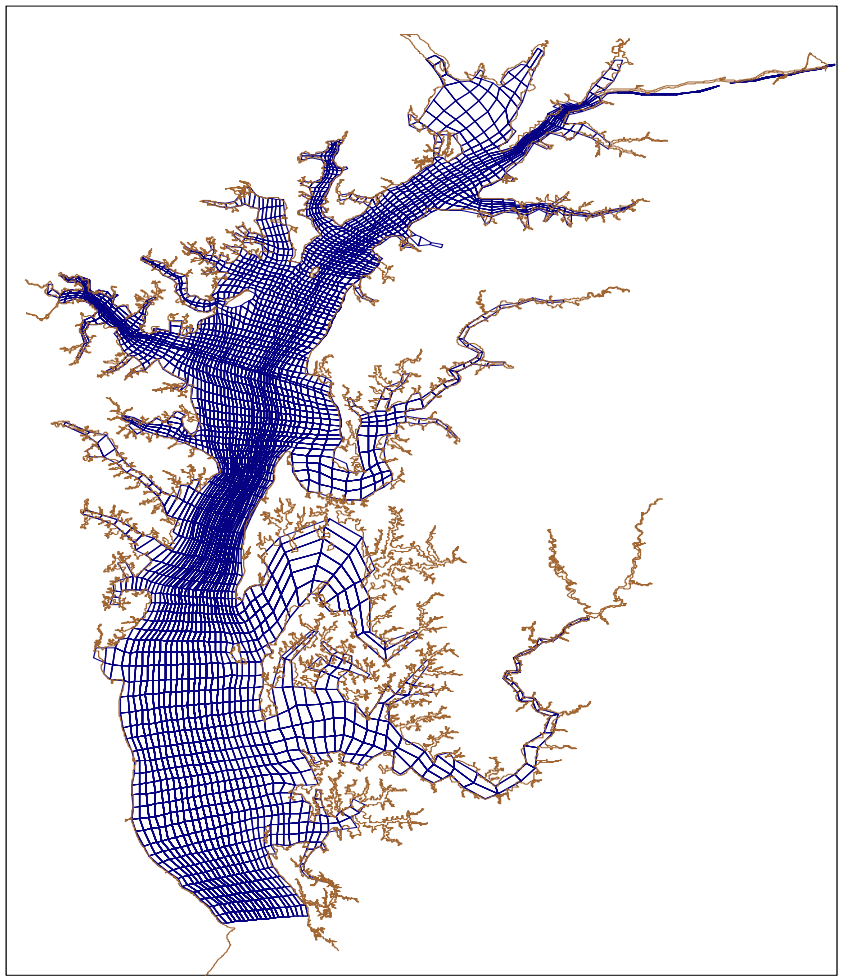


Figure 3.2 - Schematic of Contaminant Transport Box Model Processes

Upper Bay Hydrodynamic Model (VIMS)

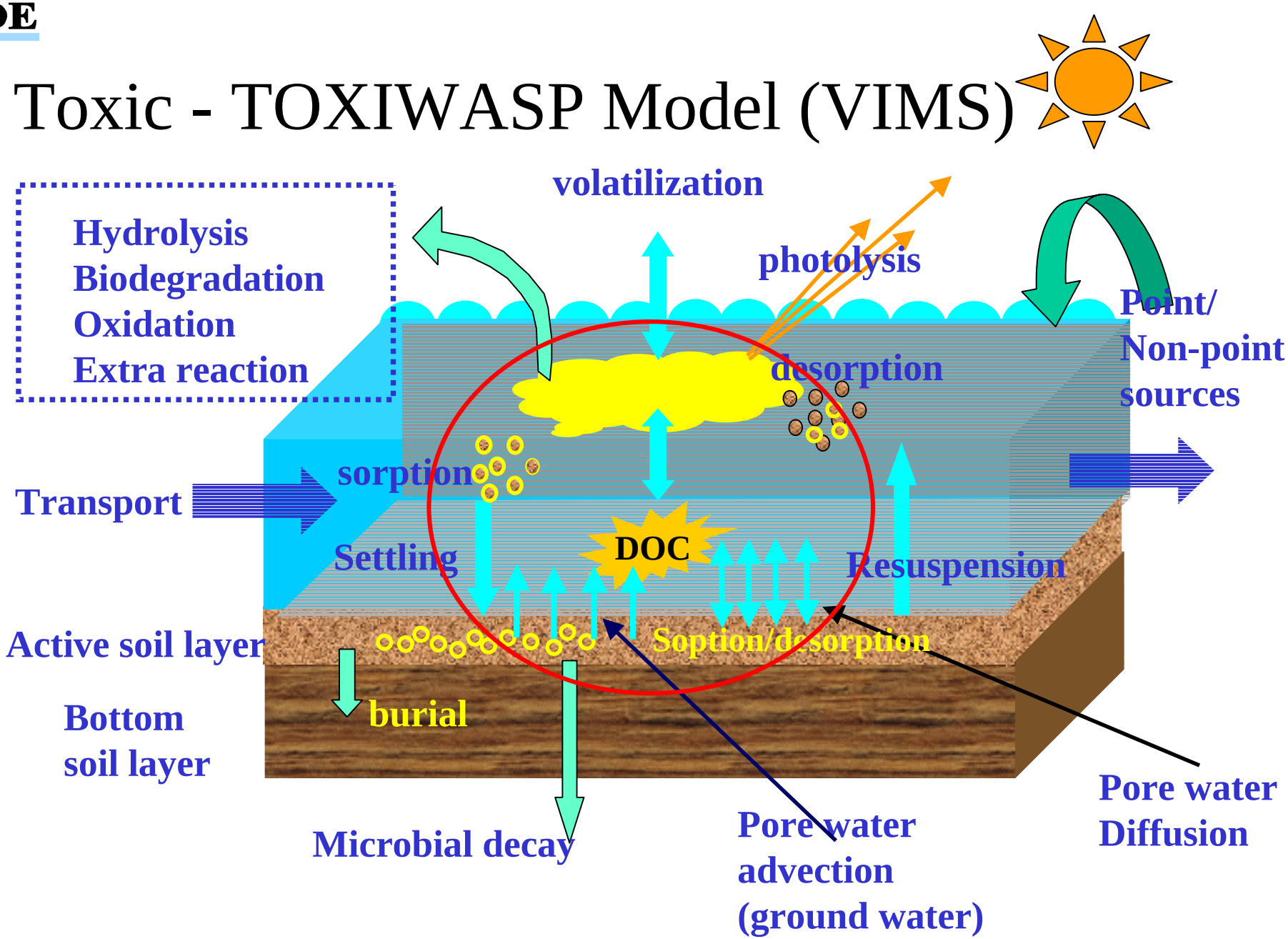
CH3D - Curvilinear Hydrodynamic 3-dimension

- CH3D
  - Velocity, Diffusion, Surface elevation, Salinity, Temperature on an intratidal time scale.
  - Model physical processes impacting bay-wide circulation and vertical mixing
    - Tides, Wind, Density (salinity, temperature), Freshwater inflow, Turbulence, Earth rotation



MDE

Toxic - TOXIWASP Model (VIMS)

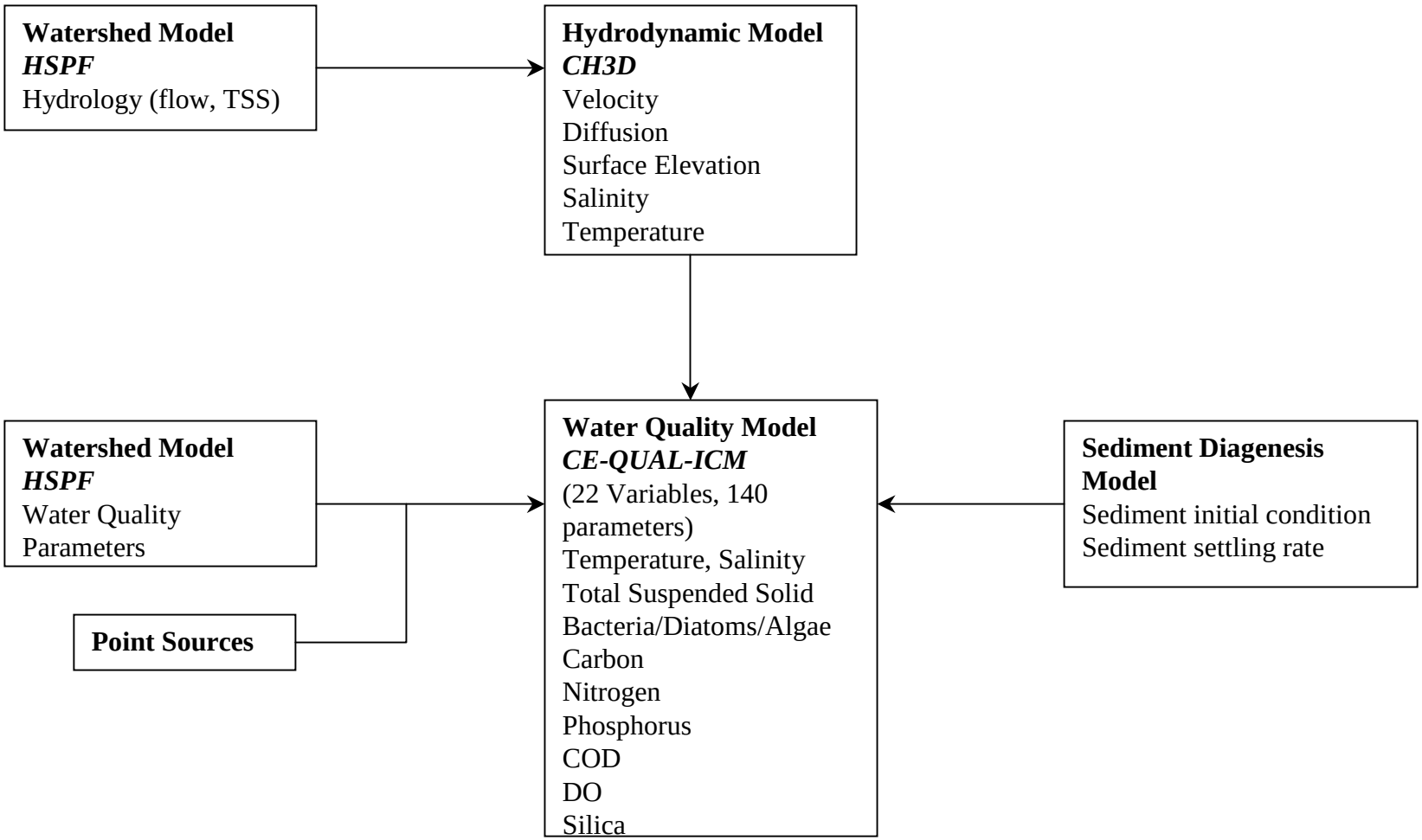


Baltimore Harbor Eutrophication Modeling

Existing Data for Nutrients

- NPDES permits
- Water column
  - MDE 94-95
  - Baltimore City Department of Public Works 97
- Benthic flux
  - Upper Bay
    - Chesapeake Bay Program 82~
  - University of Maryland 94, 95, 97

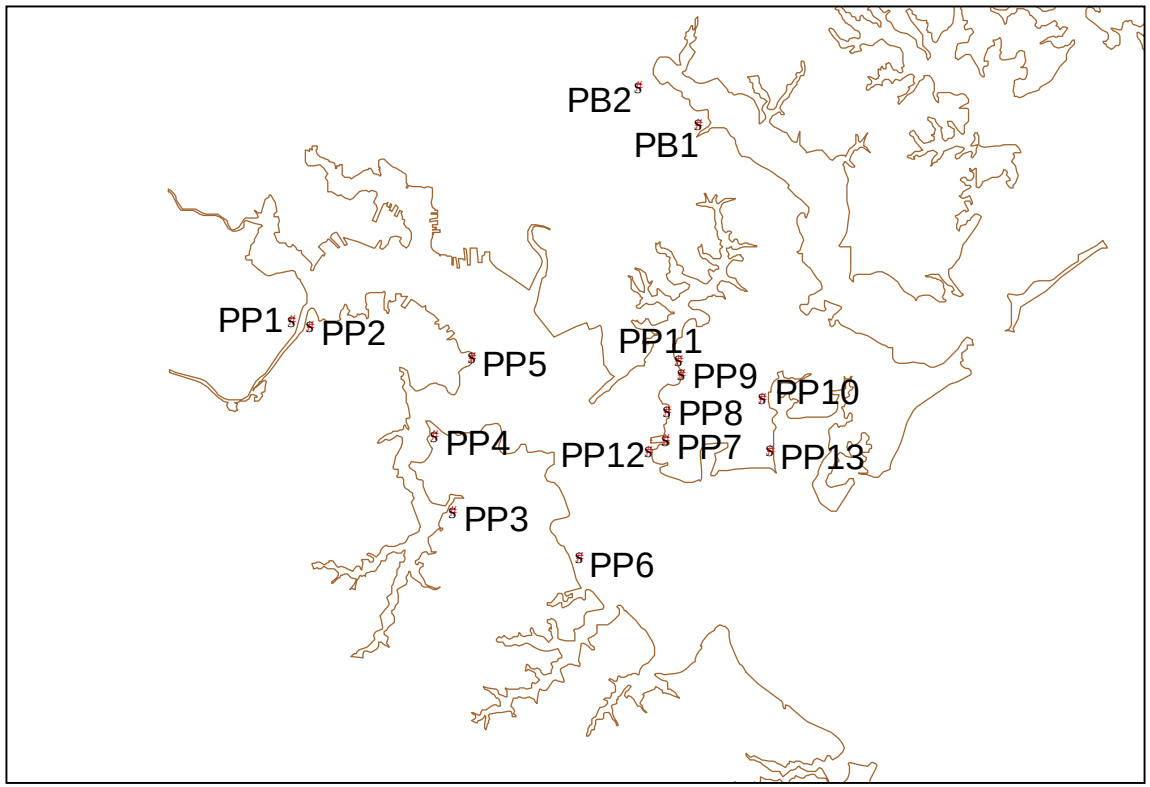
Harbor Eutrophication Modeling Framework



Eutrophication – Watershed Model

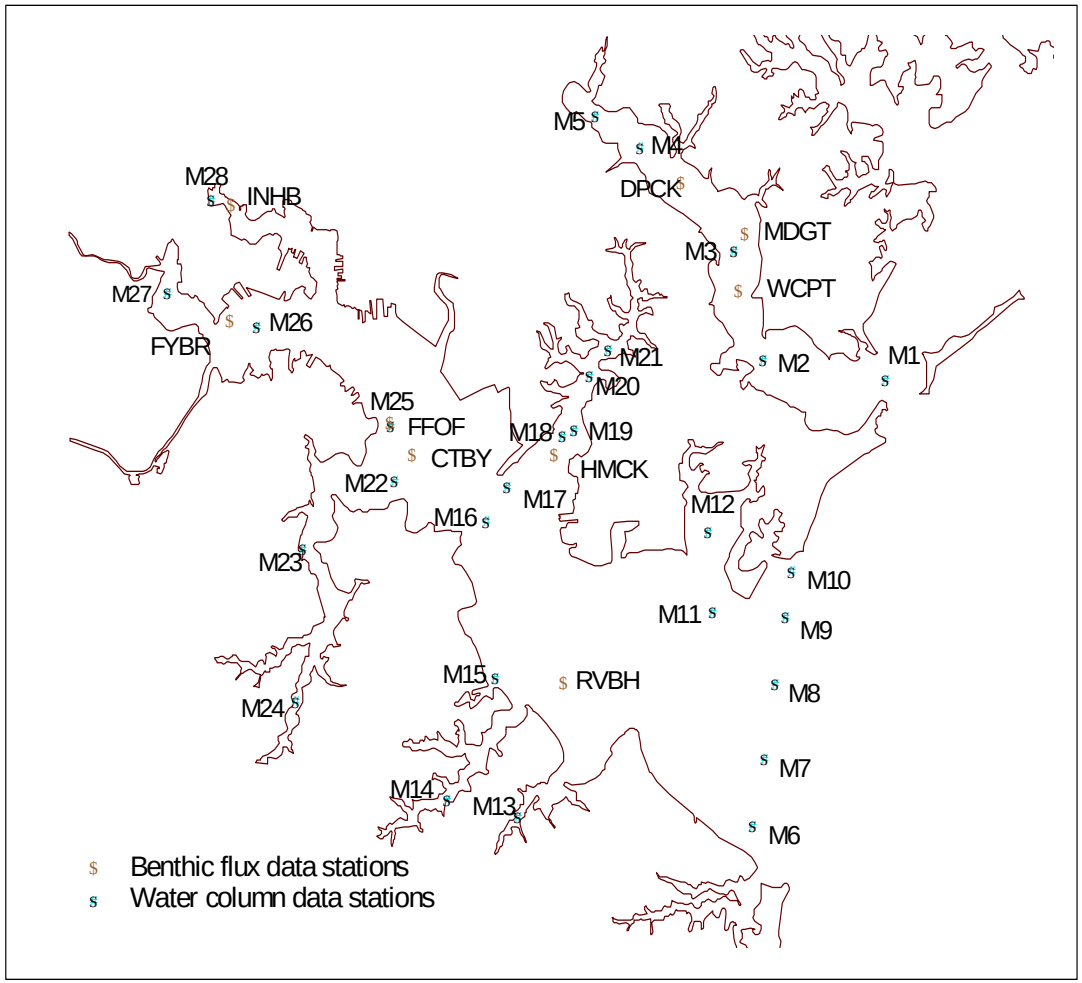
- HSPF – Hydrologic Simulation Program: Fortran
  - HSPF is used to estimate nutrient, flow, and TSS values
  - The model incorporates;
    - Seasonality
    - Meteorological Data
    - Landuse
    - Agriculture Information
    - Soil types
    - Monitoring Data

Eutrophication – Point Source Locations



PB1 = Back River
PB2 = Eastern Stainless
PP1 = Congoleum
PP2 = Freedom District
PP3 = Chemetals
PP4 = W.R. Grace
PP5 = Patapsco
PP6 = Cox Creek
PP7-PP13 = Bethelehem Steel

Eutrophication – Water Quality Sampling Stations



Baltimore Harbor Nutrients Watershed Summary

Total Delivered Load from Watershed						
	MDE(93-97)			CBP(93-97)		
	Patapsco	Back	Total	Patapsco	Back	Total
Total Area (Ac)	266,888	34,785	301,673	255,952	46,851	302,803
Total Avg Flow (MG/yr)	179,242	23,181	202,423	142,386	33,208	175,594
Total Sediment (Ton/yr)	24,651	2,125	26,776	89,407	7,298	96,705
Total TP (Lb/yr)	145,967	22,112	168,079	382,131	98,091	480,222
Total TN (Lb/yr)	2,475,009	227,201	2,702,210	3,083,647	684,778	3,768,425

- Back River Loads (Back River Watershed Water Quality Management Plan)

TN - 308,166 lb/yr
TP - 21,888 lb/yr
TSS - 3,124 ton/yr

- Back River MDE SWMM

TSS - 3,354ton/yr

Eutrophication Models

- Hydrodynamic Model – CH3D (VIMS)
  - Same model as Toxics portion

Eutrophication Models

- Water Quality Model - Corps of Engineers Water quality Integrated Compartment Model - a three-dimensional eutrophication model package including water column, eutrophication, and benthic process models

22 state variables, 140 parameters

- Temperature, Salinity, Total suspended solids
- 3 algae groups : Dinoflagelete , Diatoms, Other (green) algae
- Carbon cycle : DOC, LPOC, RPOC
- Nitrogen cycle : Ammonium, Nitrate-nitrite, LPON, RPON
- Phosphorus cycle : Total phosphate, DOP, LPOP, RPOP
- Silica cycle : Available Silica, Particulate Biogenic Silica
- COD
- DO

Current Model Status

- Eutrophication Model
  - Watershed (HSPF) – Final Stage (External Review)
  - Hydrodynamic (CH3D) – Calibration done
  - Water Quality/Sediment (CE-QUAL-ICM/CB Sediment flux) – Calibration

- Toxic Model
  - Watershed (SWMM) – Final Stage (External Review)
  - Hydrodynamic/Sediment Transport (POM, CH3D) – Calibration
  - Toxic/Food Web (Toxic Box, Toxiwasp) – Under construction

MDE

Future Actions

2002

- Complete CHARM point source sampling – finalize data report
- Continue work on calibrating hydrodynamic and water quality models
- Work with Stakeholders

2003

- Develop scenario runs – develop allocation options
- Finalize TMDLs and submit to EPA
- Work with Stakeholders